



Chadwick GreenBIM

Advancing Operational Understanding of existing buildings with BIM

Dietmar Backes, Charlie Thomson, Dr Jan Boehm, Prof Robson et.al.

3DIMPact

3D Imaging, Metrology & Photogrammetry
Applied Coordinate Technologies



Overview and Agenda

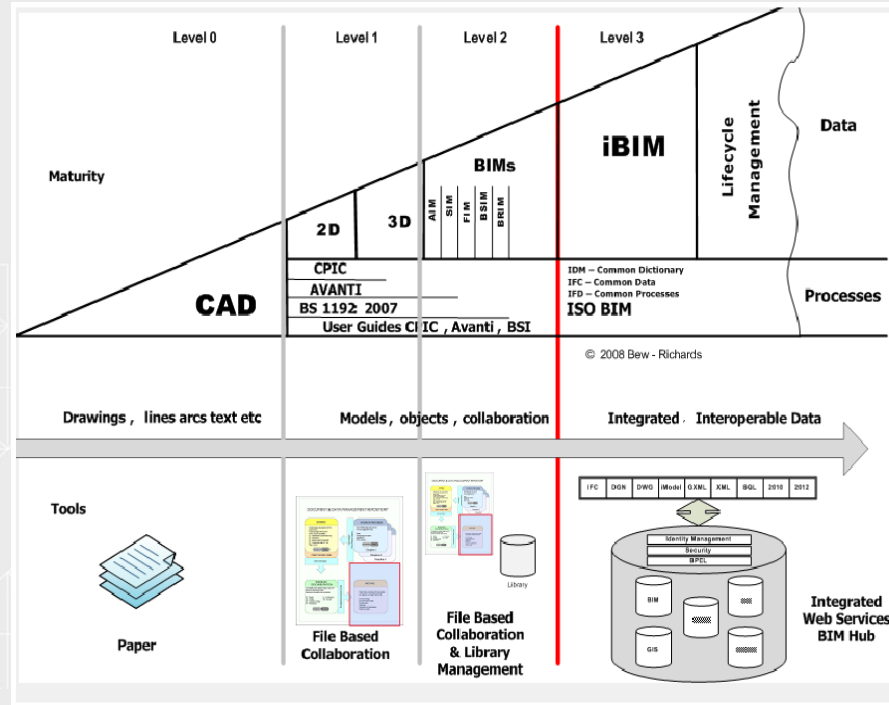
- (Green)BIM,
 - Introduction Overview Aims
 - Project status
 - Results of Phase 1
 - Lessons been learned
- Indoor Mobile Mapping - Innovative Ways to Scan
- Geomatic BIM education

Introduction

- BIM hype in UK seems to continue
- European Directive Officially Opens Public Procurement to use BIM
- (Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing Directive 2)



Bew-Richards diagram



Chadwick GREEN BIM

- The building:
 - Grade 1 listed building in need of modernisation
 - Work environment in need of improvements
 - Poor sustainability performance
 - Patchy Building documentation
- Expertise:
 - Still segregated
 - Often duplicated across organisations



Chadwick GREEN BIM

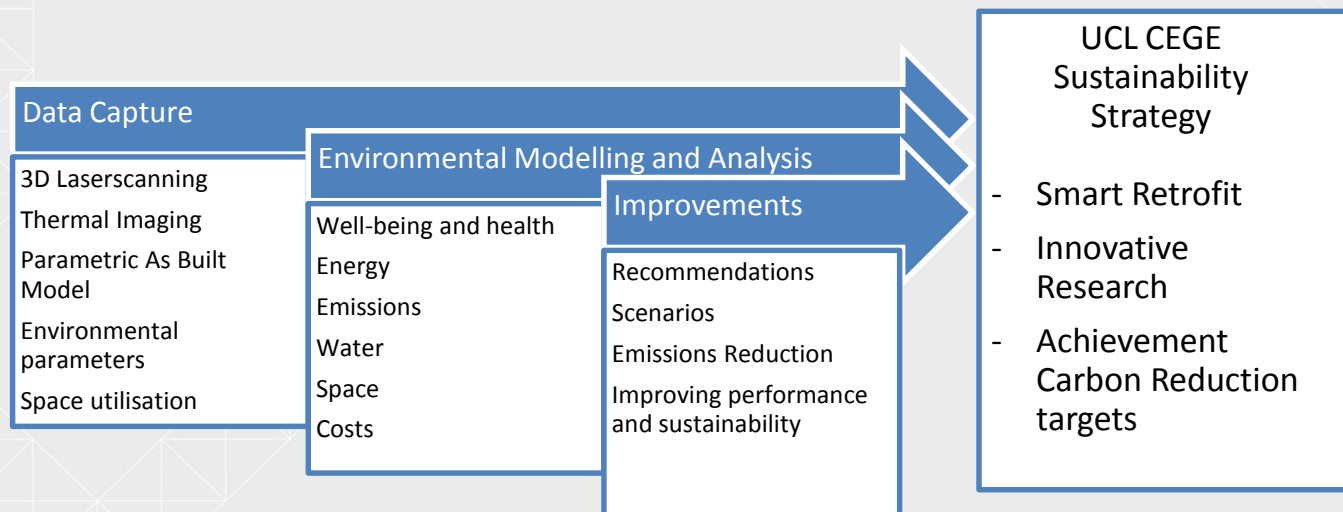
Motivations and Ambitions:

- Grass root approach
- Interdisciplinary approach - Involving people:
 - students as well as academics
 - Integration and cooperation across all disciplines
- UCL Estates and facilities: show case and living Lab idea
- Exploring ways for collaborative research
- Improving sustainability and work environment in Chadwick building



Chadwick GREEN BIM

- A detailed Case study of UCL Chadwick building





Chadwick GREEN BIM – building the initiative

- Research into BIM started in the scope of cooperation with FARO
- Vibrant Green Group keeps winning awards
- Decision to develop the Topic systematically in four focus Groups
- CEGE, the Faculty of Engineering and Estates and Facilities jointly agreed funding for a first Phase to build Chadwick GreenBIM



Chadwick GREEN BIM – Phase 1

Comprehensive data collection including As build documentation:

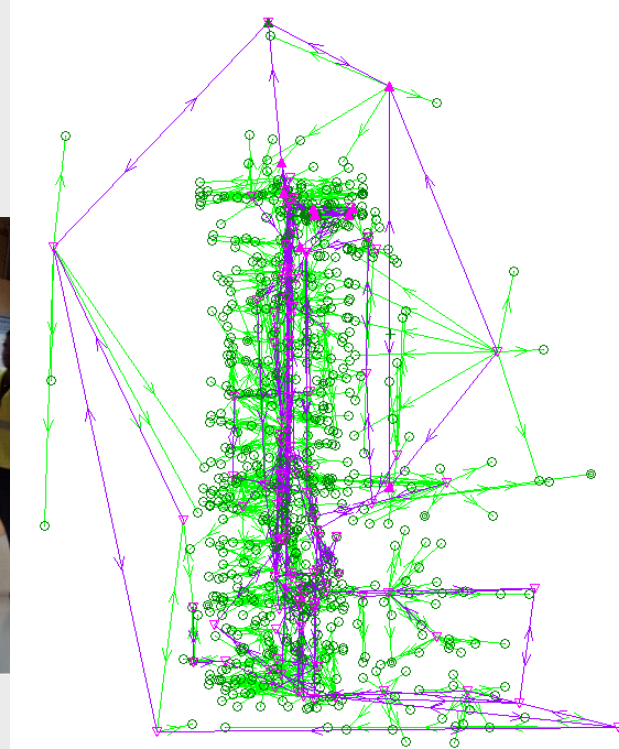
- External data: Space borne, airborne, mobile mapping
- Internal Complete 3D Laserscan of the building
- Collecting environmental data
- Establishing a space utilisation monitoring scheme
- Collecting further information from any source possible (Estates and Facility records)

3D Laserscanning concept:

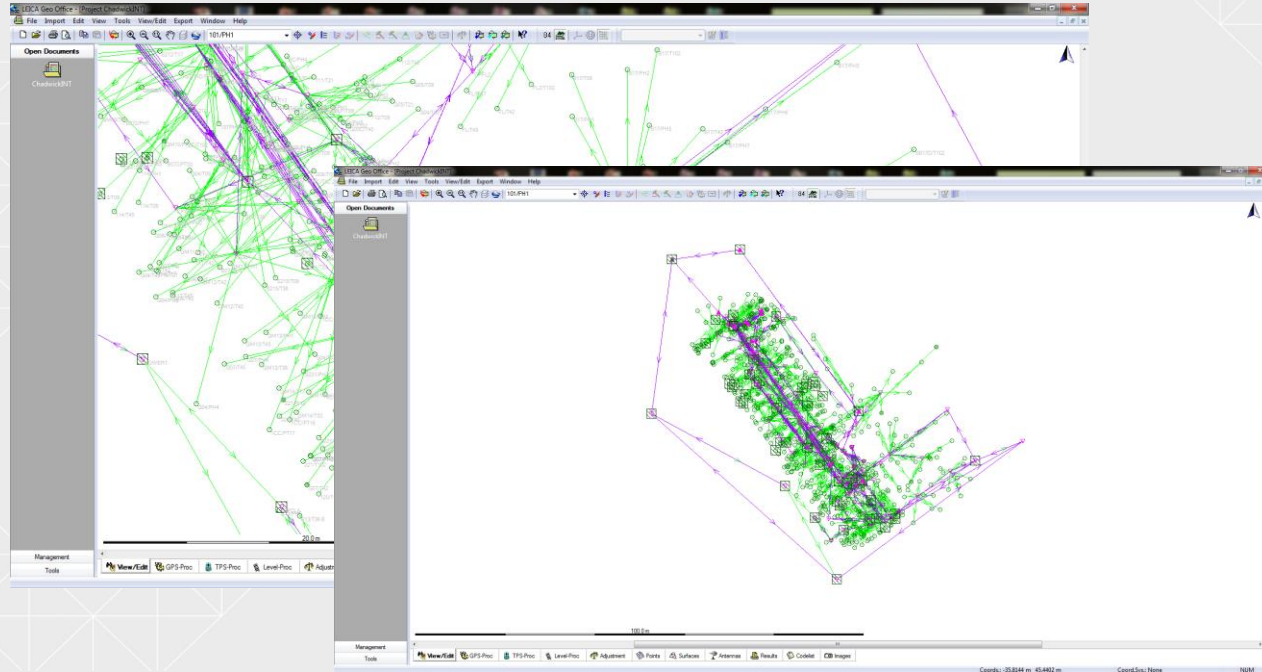
- Registered using a traditional survey network
- Surveyed reference system to guarantee geometric fidelity



Rigorous Survey Network:



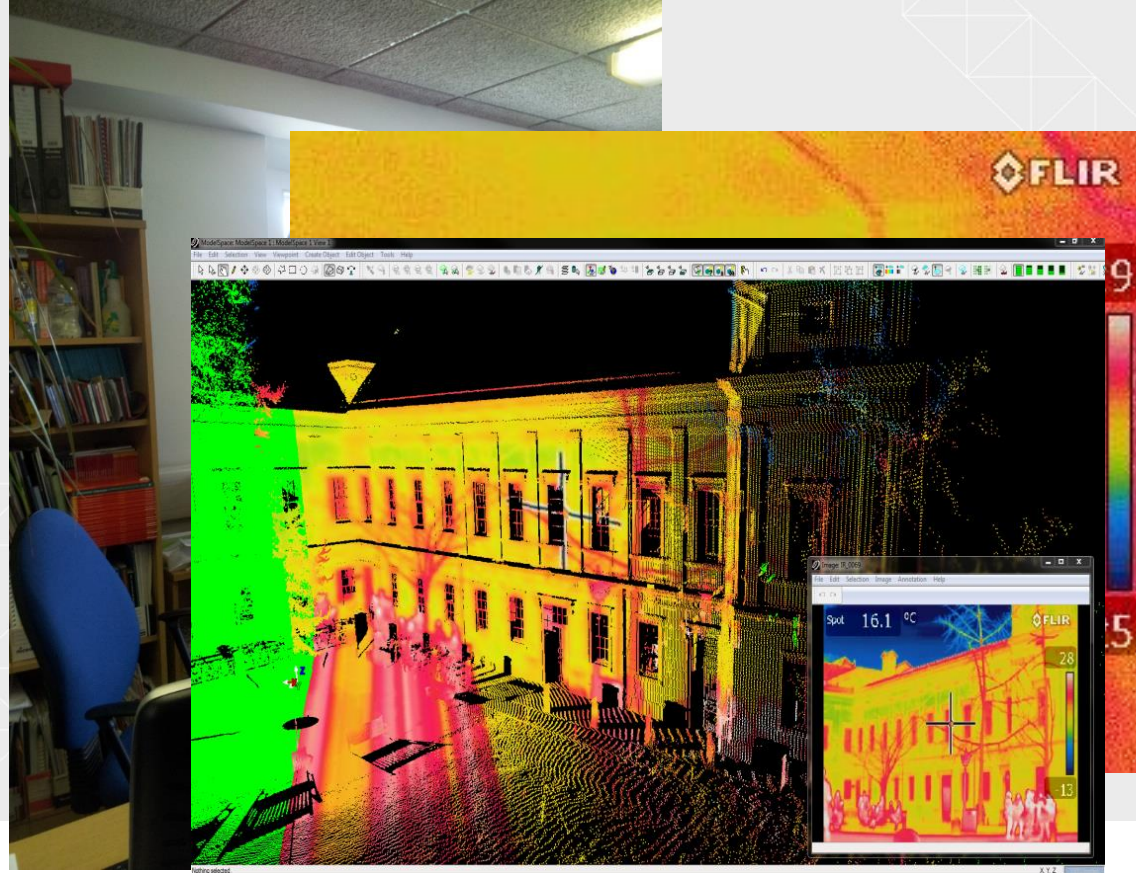
Rigorous Survey Network:



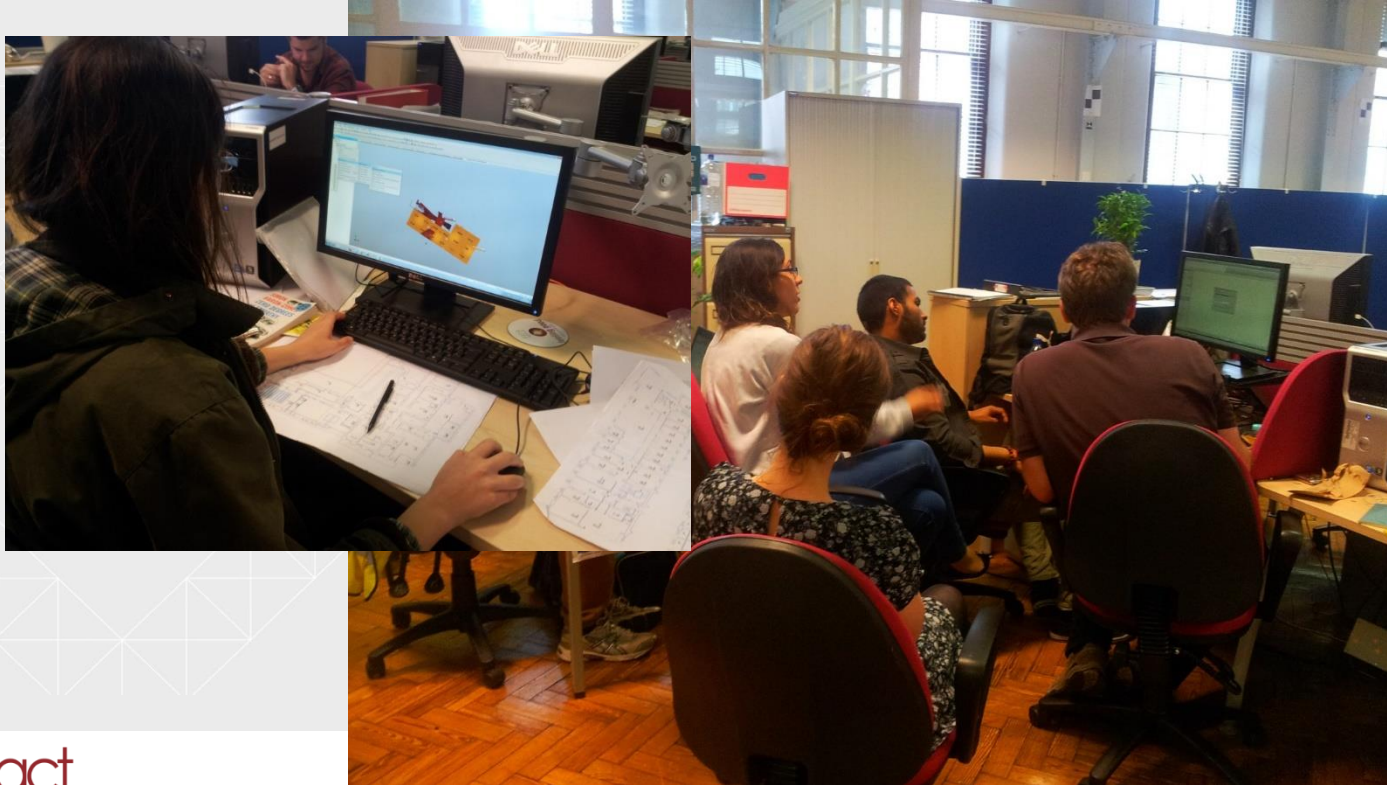
The Scans:



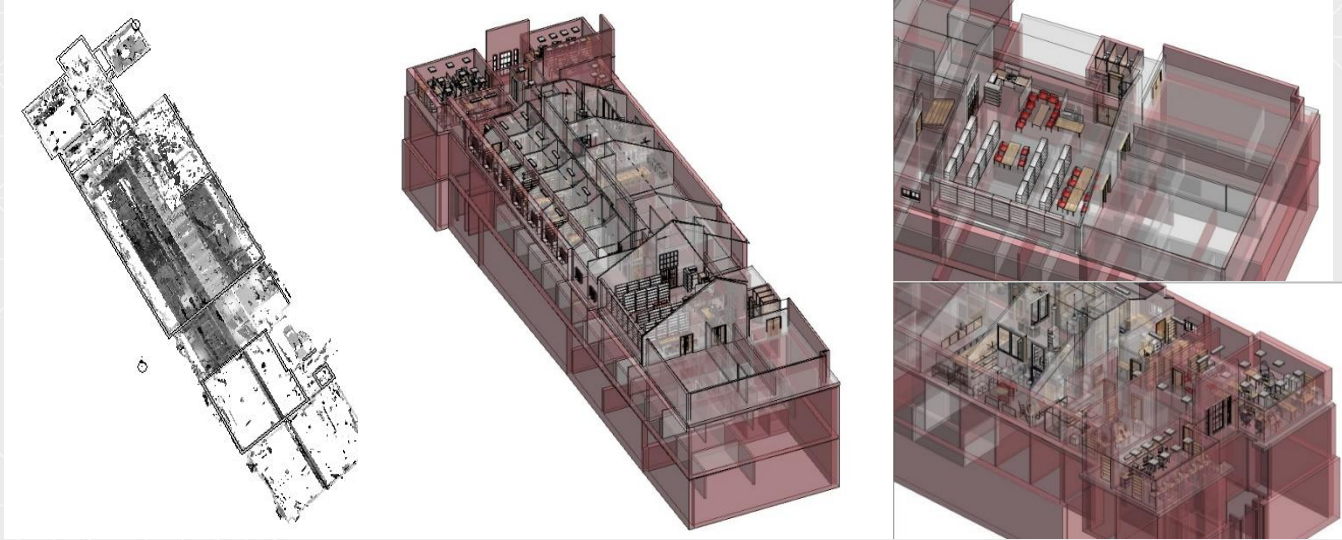
Thermal Images:



Point Clouds based modelling in Revit:



Point Clouds based modelling in Revit:

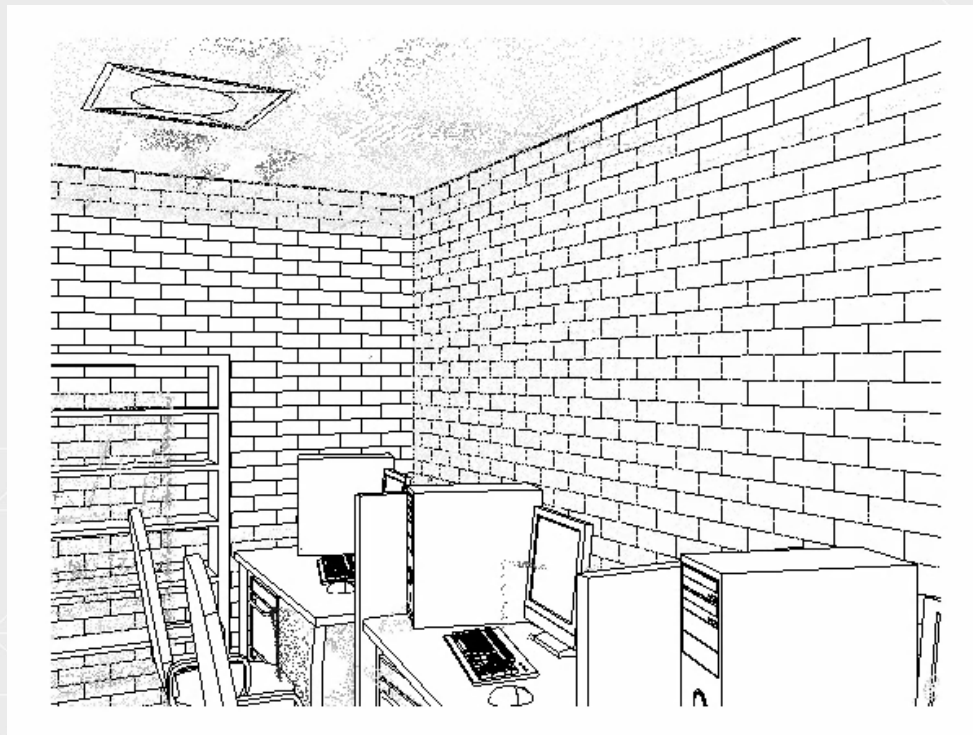




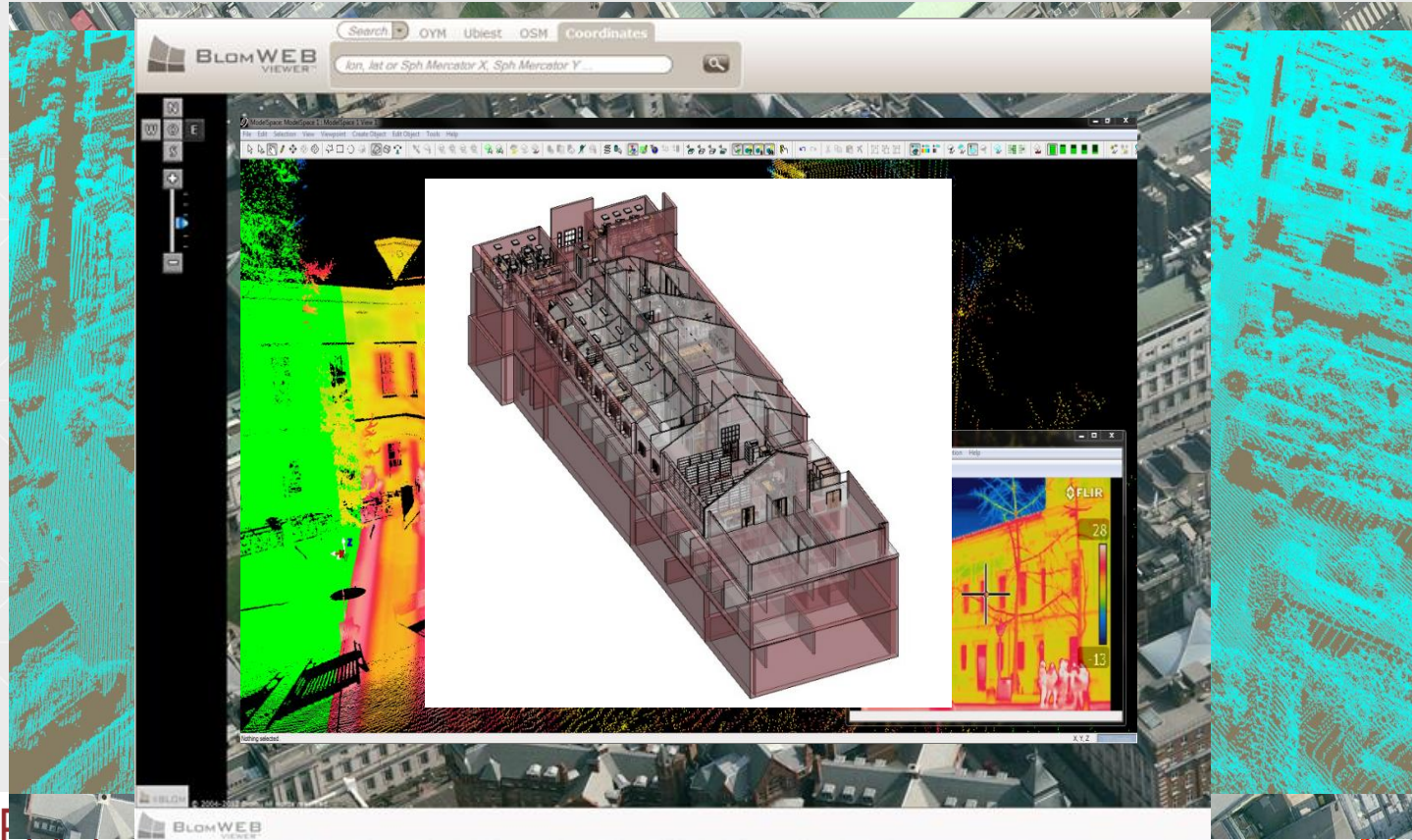
Some results:



Some results:



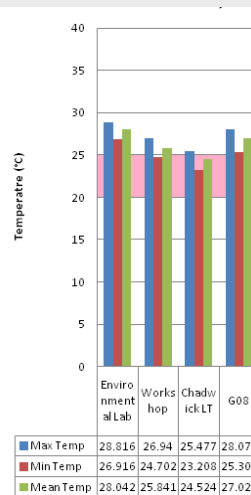
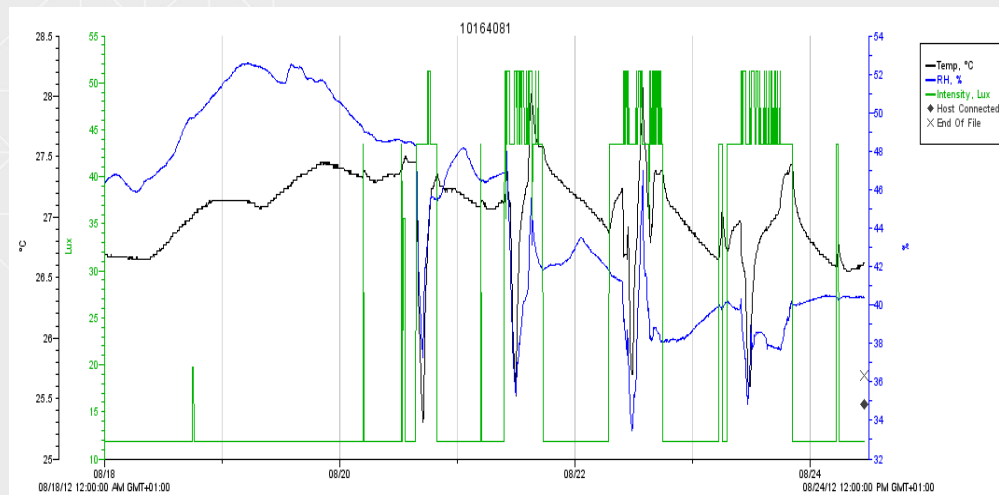
Chadwick GREEN BIM – Multiple Scales



Application Environmental Comfort Analysis

Sensor Network:

Temperature, Light Intensity and Relative Humidity

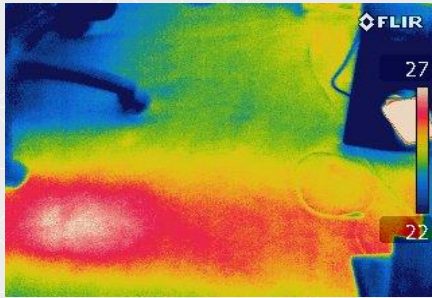


Currently 20 Sensors were placed in chosen rooms around the building, with the aim to represent the variation in working conditions across a variety of room function and occupation.

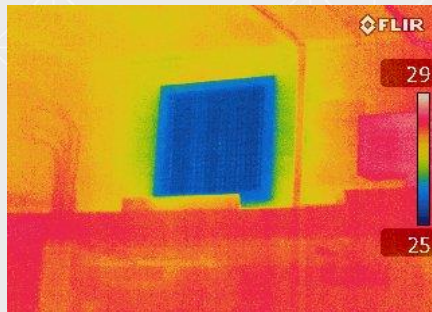
The data collected will also be used to validate future CFD and thermal models.

Application Environmental Comfort Analysis

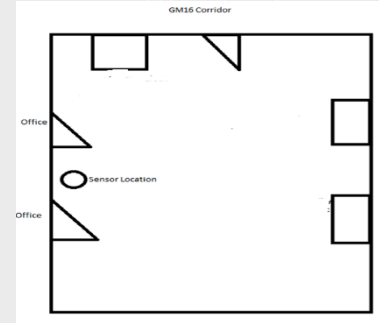
Thermal Imaging and Airflow measurement



A thermal image camera was used in the 20 rooms which contain sensors. Through the thermal imaging process hot and cold spots could be seen. This will help give an idea about the thermal gradients which exist within the building.



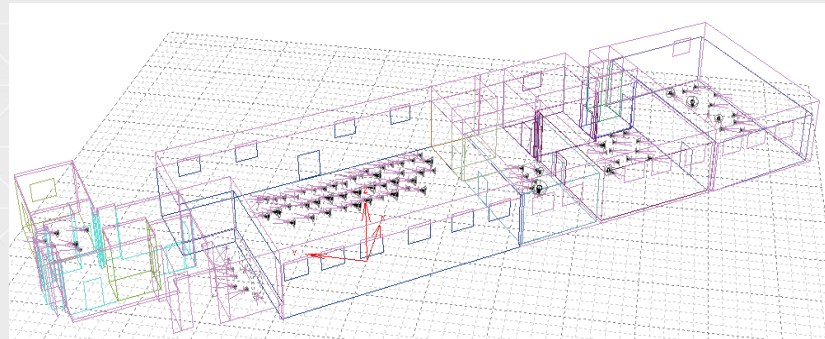
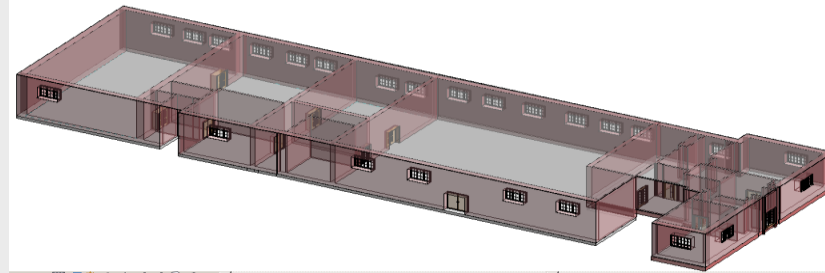
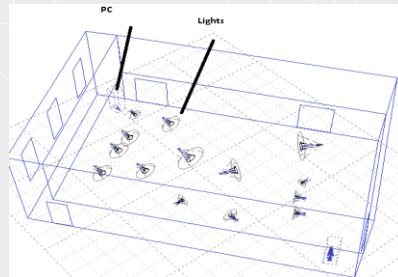
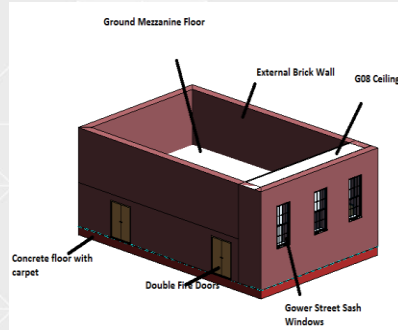
Air vents within the 20 rooms were assessed to see the direction of flow (if any) and the thermal image camera was used to visualise the temperature of the air



Using an Anemometer, the volumetric flow rate , velocity and temperature of air entering/exiting the vent was measured. In general, it was found the many of the vents were dysfunctional, only 2 rooms could be considered to have adequate ventilation.

Application Environmental Comfort Analysis

Comfort Analysis: Simulation vs. real Measurements

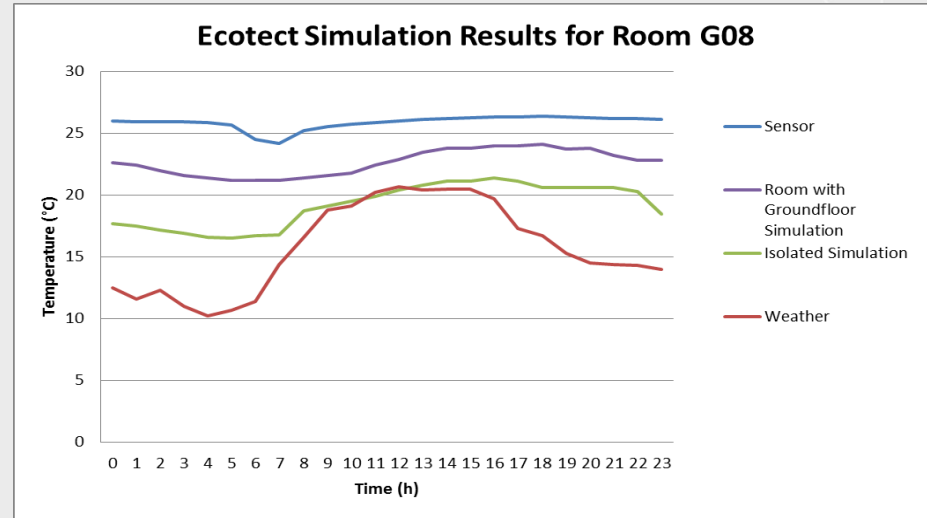
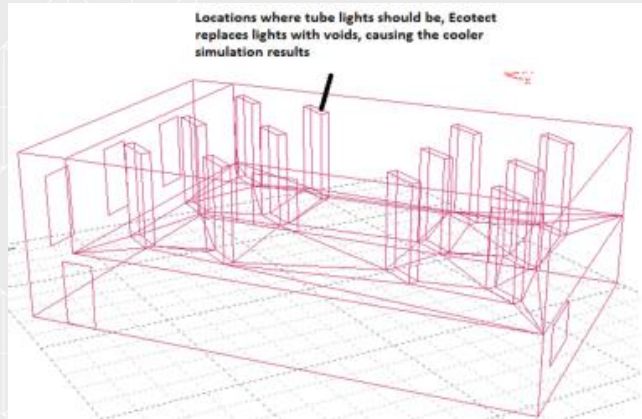


The next phase of the project will involve the use of the created Parametric model as the dataset in CFD simulations and thermal modelling.

To progress to the next phase the validity and reliability of software and modelling techniques were assessed.

Application Environmental Comfort Analysis

Comfort Analysis: Simulation vs. real Measurements

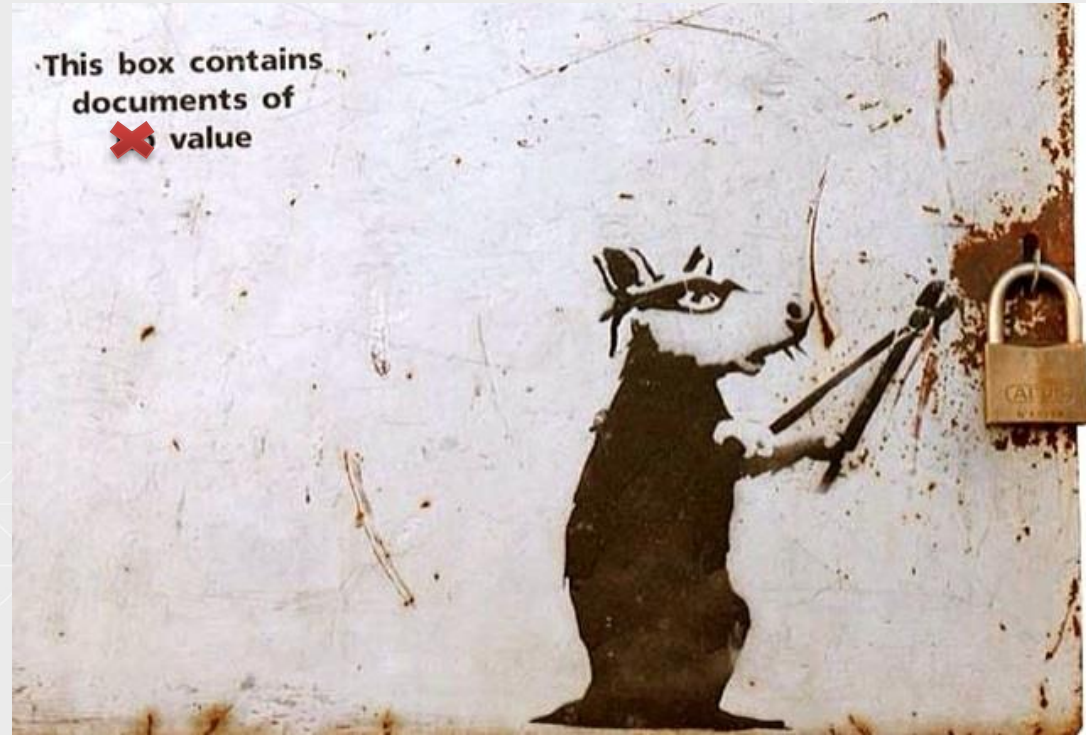


Lessons learned:

- Labour intensive
 - Static Scanning takes to long
 - Post processing
- Rigorous data Management is required
 - For new collected data and legacy data
 - Documentation and Quality assessment
 - Bim maturity Level3 remains the “Holy Grail”
- Interdisciplinary Interfaces and requirements
 - Need to be defined
- A specialised Skillset is required!



Lessons learned:





Emerging Indoor Mobile Mapping (IMMS)

Master Thesis by Georgios Apostolopoulos



Emerging Indoor Mobile Mapping (IMMS)

Driven by:

- Technical advances and innovation by a vibrant robotics and computer vision community
- the need of more efficient/rapid 3D data capture solutions for fast Scanning campaigns (Ref. Rechenbach)
 - Kinematic systems; automated
 - Automated Pre-Processing incl. registration georeference
- Requirements of range of identified applications
 - Trade of between speed and accuracy
 - Environmental simulations, asset, space and change management etc.



Emerging Indoor Mobile Mapping (IMMS)

Aims of the study:

- 1) To assess the performance of indoor mobile systems against a traditional survey workflow.
- 2) To investigate the quality of the generated point clouds and the ability to design accurate geometry for BIM applications.
- 3) To provide a starting point for discussion.
- 4) Further development and exploitation of the systems.

Overview of current Systems

Trolley-Based



Robotic



Hand-held



Experimental (?!)

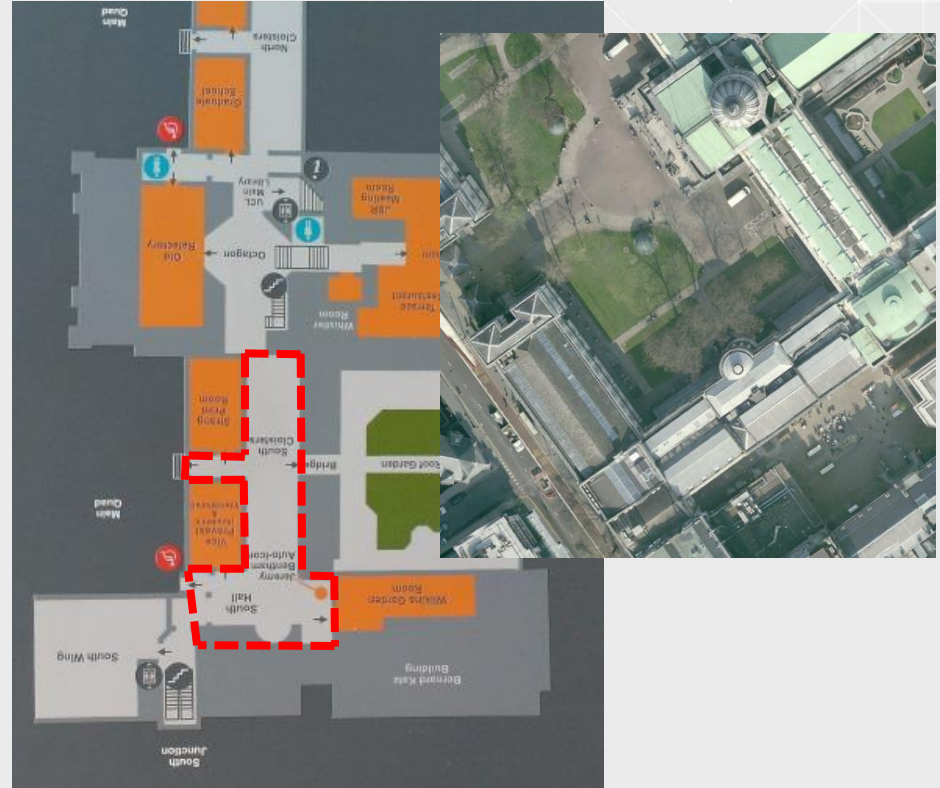


Study areal

- Long corridor (39×7×5 m).
- Repetitive, but clean structures.
- Frequent pedestrian traffic.



South Cloisters of UCL



Static Solutions: Focus3Ds & Leica TS15

Focus3D:

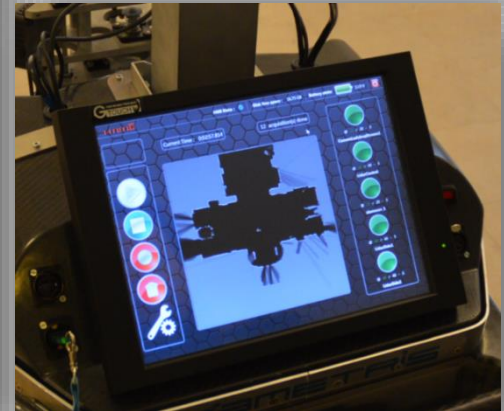
- A state-of-the-art scanner commonly used for building surveys.
- Its light weight and compactness make it ideal for indoor applications.
- Data are treated as the reference due to higher accuracy and density.

Leica TS15:

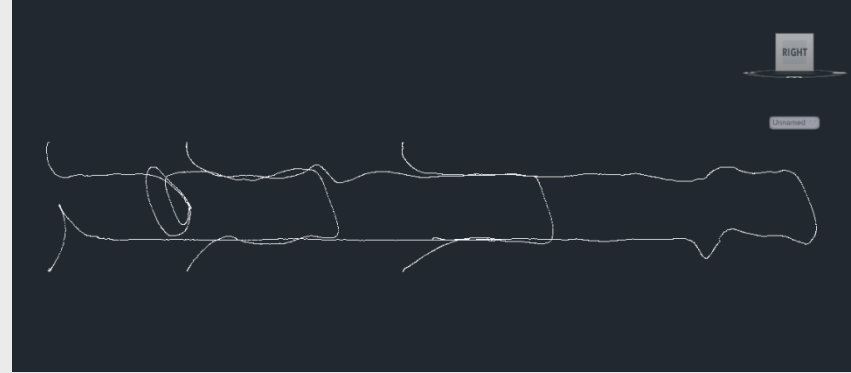
- To establish a control network where the results can be compared.
- A method still used for building surveys.
- Georeference of Focu3D data.



Trolley based IMMS: Viametis i-MMS



Trolley based IMMS: Viametis i-MMS

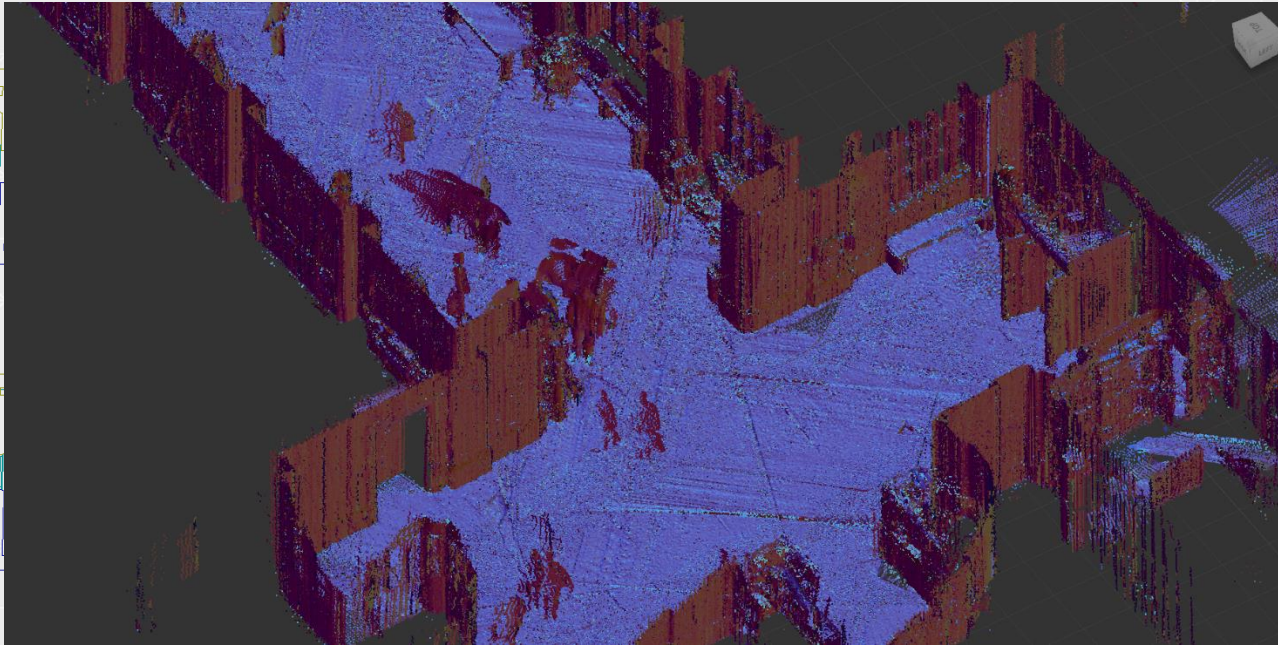


System based on “3D Lidar” vision SLAM:

- Small and compact
- Inexpensive fast solution
- Slam algorithms are complex and still subject to R&D (fast progress)



Viametris iMMS - Trajectory overlay

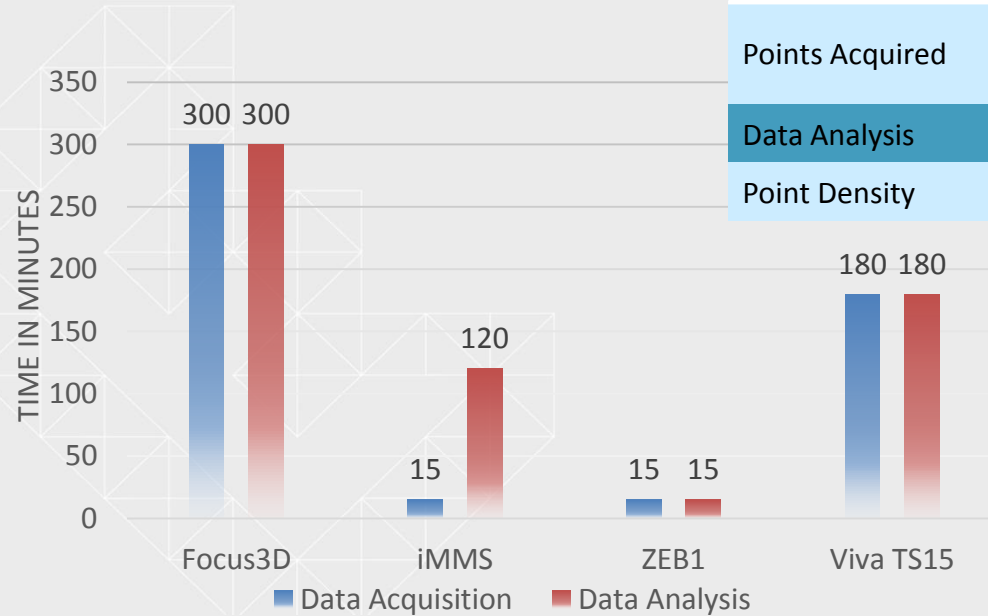


IMMS: CSIRO Zebedee/GeoSlam Zeb1





Data Acquisition & Analysis



	Focus ^{3D}	iMMS	ZEB1	Viva TS15
Points Acquired	90 million in 5 hrs	18 million in 10 min	8 million in 10 min	120 points in 3 hrs
Data Analysis	5 hrs	2 hrs	10 min	3 hrs
Point Density	1 - 2 mm	6 - 12 mm	8 - 25 mm	-

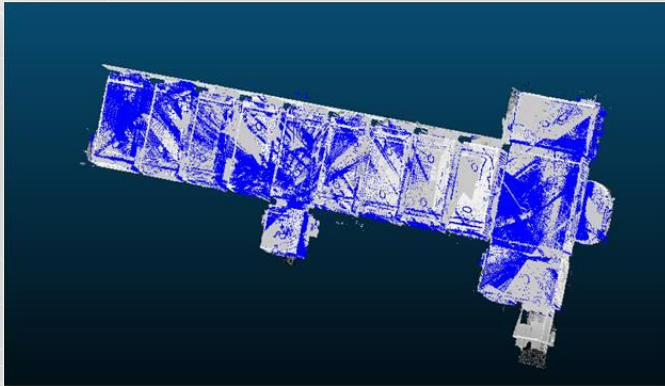
Analysis: Point Cloud Comparison

- Focus 3Ds point clouds were the reference data due to higher density and accuracy, while iMMS and ZEB1 were the compared.
- iMMS and ZEB1 data were aligned to Focus^{3D} with the ICP algorithm.
- Distance differences were calculated between corresponding points.

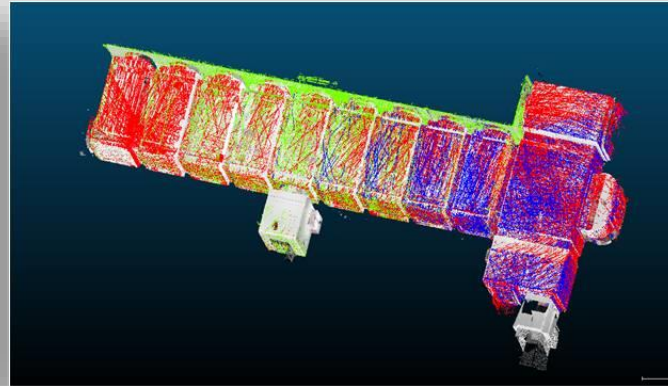
ICP algorithm			Deviation using the Height Function		Deviation using the Least Square Planes	
	Focus ^{3D} -iMMS	Focus ^{3D} -ZEB1	Focus ^{3D} -iMMS	Focus ^{3D} -ZEB1	Focus ^{3D} -iMMS	Focus ^{3D} -ZEB1
RMS (m)	0.0253	0.0259	-	-	-	-
Mean (m)	-	-	0.0278	0.0354	0.0264	0.0320
St. Dev. (m)	-	-	0.0545	0.1880	0.0421	0.1091

Georeferencing

- The point clouds from the various systems transformed to the same coordinate system through the ICP method prior to modelling.
- Artefacts in the scans caused by people and glass, as well as non – overlapping areas were removed prior to alignment



Registration of the Focus3D and i-MMS point clouds



Registration of the Focus3D and ZEB1 point clouds

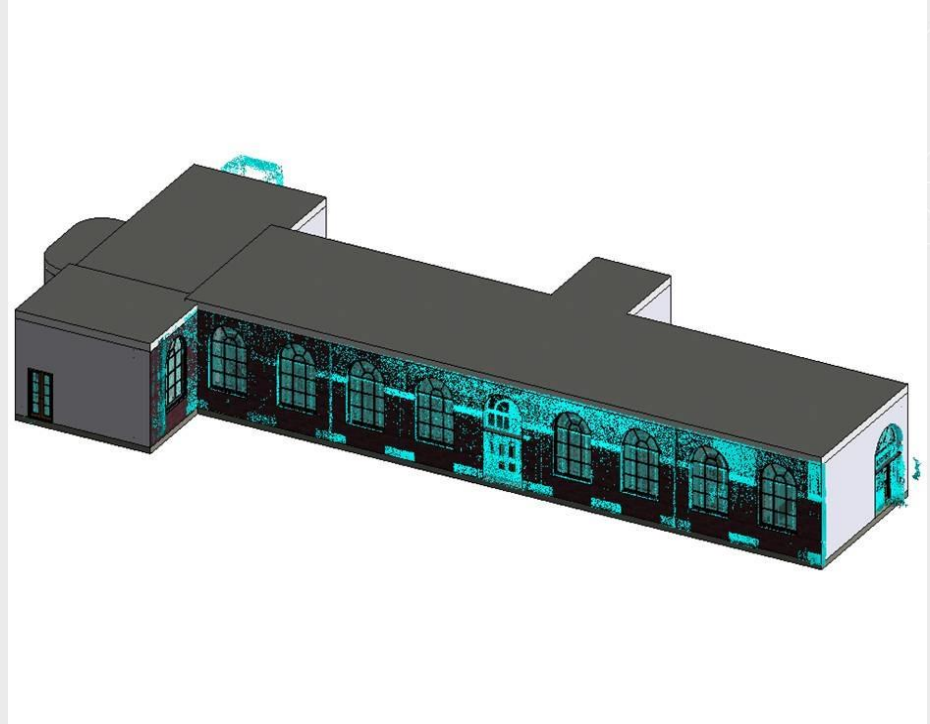
Modelling

- Models were designed in Revit Architecture 2014. Point clouds have to be converted in the proprietary RCS format, before import to Revit.
- Specific elements were selected and the comparison was based on the calculated dimensions.
- The quality of the underlying point clouds affects the modelling procedure.
- A LoD 3 has been chosen, corresponding to a point spacing of 10 mm.



Modelling

- Primary focus was given to model the basic detail of elements.
- Materials and structural elements were excluded.
- Verticality & perpendicularity of walls was not taken into account. The modelling based solely on underlying point clouds.



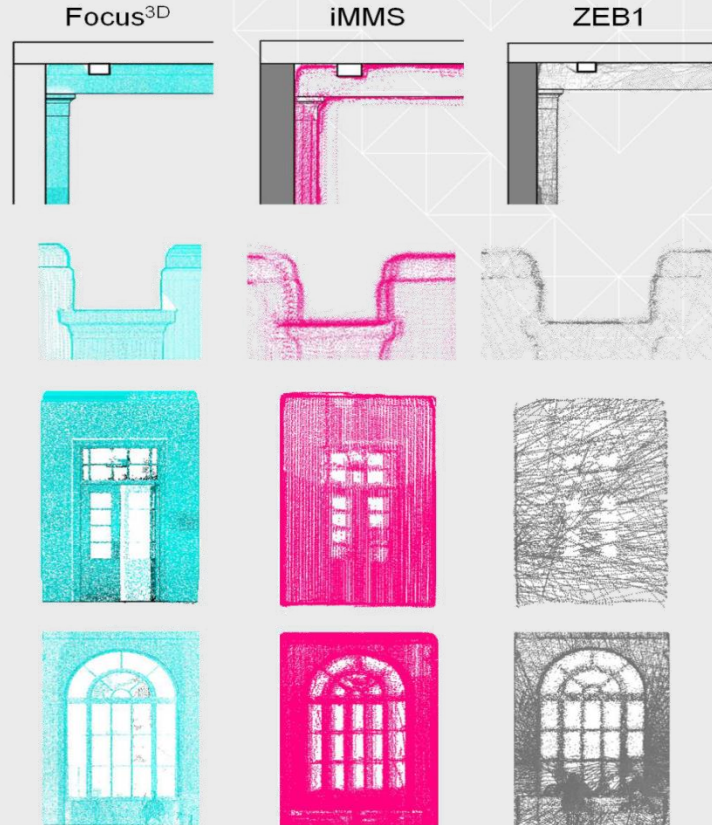
Modelling

Differences based on 10 door elements

	Mean (width)	Mean (height)
Focus^{3D} – iMMS	0.051 m	0.044 m
Focus^{3D} – ZEB1	0.064 m	0.046 m
Leica TS15 & tape measures – iMMS	0.059 m	0.050 m
Leica TS15 & tape measures – ZEB1	0.070 m	0.049 m

Differences based on 7 window elements

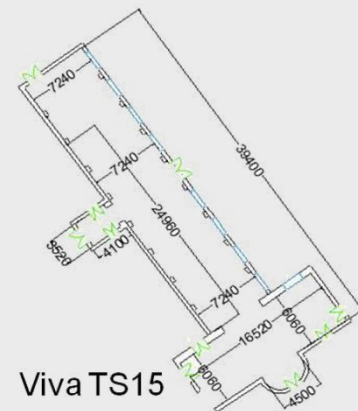
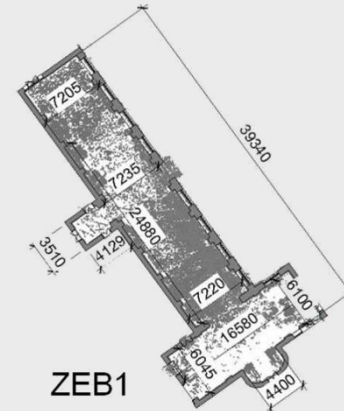
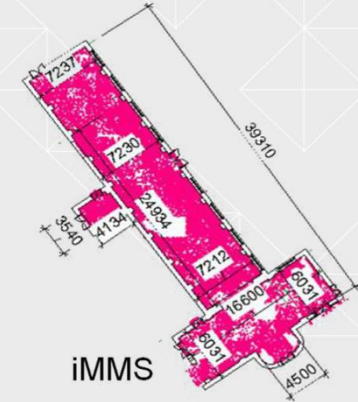
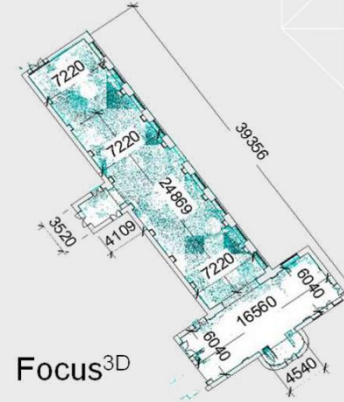
	Mean (width)	Mean (height)
Focus^{3D} – iMMS	0.035 m	0.027 m
Focus^{3D} – ZEB1	0.058 m	0.047 m
Leica TS15 & tape measures – iMMS	0.050 m	0.033 m
Leica TS15 & tape measures – ZEB1	0.069 m	0.039 m





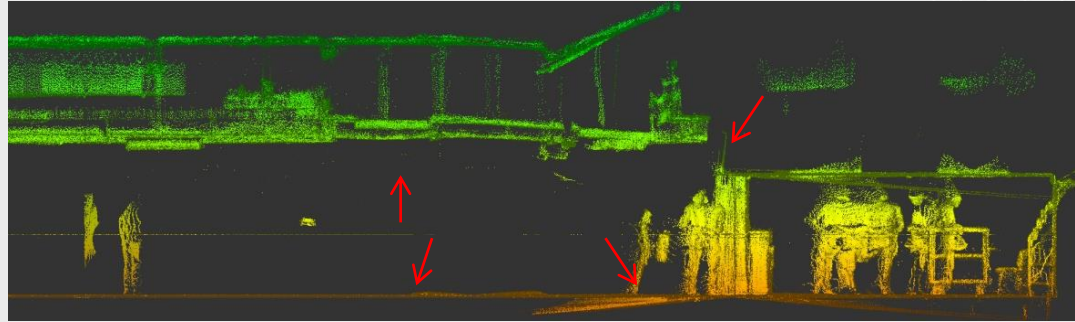
Modelling

	Differences based on lengths	
	Mean (length)	Max (length)
Focus ^{3D} – iMMS	0.026 m	0.065 m
Focus ^{3D} – ZEB1	0.028 m	0.140 m
Leica TS15 & tape measures - iMMS	0.032 m	0.090 m
Leica TS15 & tape measures - ZEB1	0.041 m	0.100 m

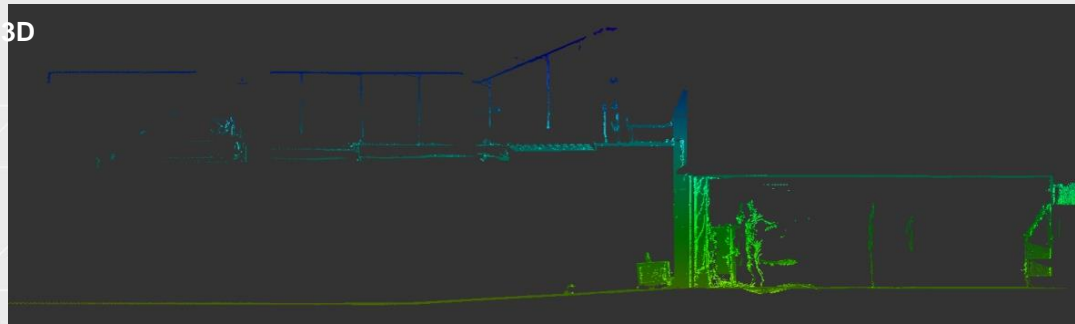


Results

iMMS

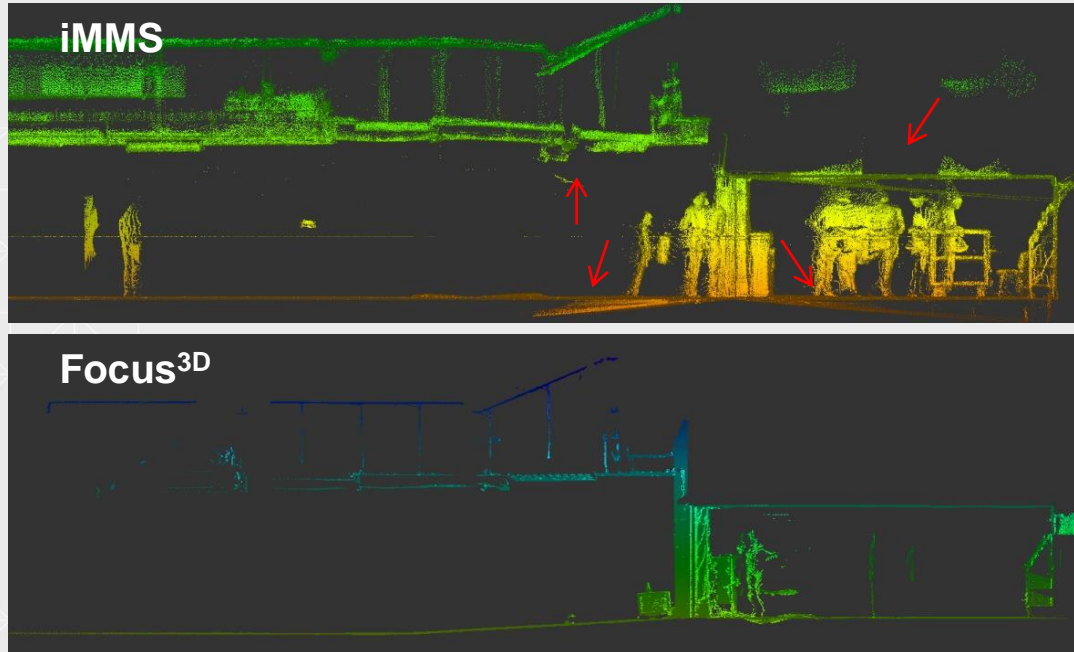


Focus^{3D}



- ◆ iMMS is restricted to 2D plane and a small change in the height can degrade the results.

Results



- ◆ iMMS is restricted to 2D plane and a small change in the height can degrade the results.

Possible Applications

- ✓ Rapid data capture for asset management.
- ✓ Room planning.
- ✓ Maintenance operations.
- ✓ Operational information and supervision during building construction.
- ✗ Monitoring applications and deformation analysis.
- ✗ Architectural reconstruction.
- ✗ Not for featureless open areas and tunnel like environments.



Future Work

- UCL has bought a new iMMS from Viametris.
- Close collaboration between Viametris and UCL researchers to mitigate the limitations of the system.
- Integration of an IMU unit to the system, so as to make it fully 3D.
- Integration of a Faro laser scanner as an extra profiler.
- Total station tracking.
- Calibration of the system in a laboratory environment.



So what is next?





BIM education

Skills required!

- MSc Geomatic BIM:
 - We created a new dedicated MSc Programme called Geomatics for BIM (first intake 2014)
- New applied BIM module
 - First cohort capped to 25 students (oversubscribed by 2/1)
 - Competitive

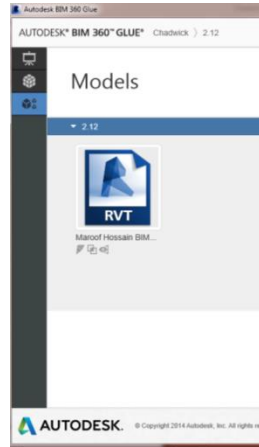
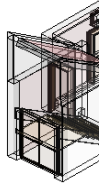


Student projects:

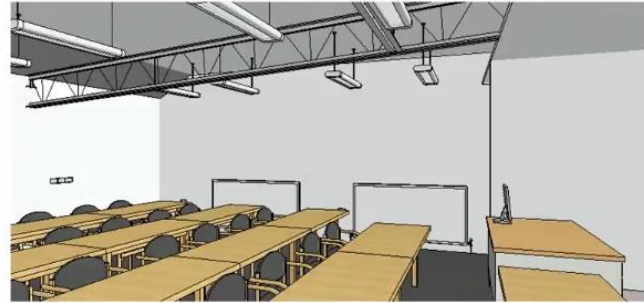
- Self directed project: students work in groups competitive to each other and deliver a result to a client.
- 4 Groups:
 - 2 groups used the Focus 3Ds.
 - 2 groups the Viametris iMMS.
- Students shall apply standard technologies introduced and investigate aspects of the project further

Some results:

Mobile



YouTube



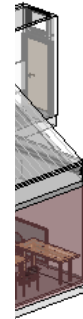
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Analytics

Video Manager

Chadwick 2.18 BIM Walkthrough

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<https://www.youtube.com/watch?v=EttstT6O4CA&feature=youtu.be>



Some Conclusions

BIM will be a vibrant area for the foreseeable future.

Technology will continue to accelerate:

- Change the way we work.
- Encourage cooperation and multidisciplinary cooperation.

New Perspectives for young people